Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Creation of a software and hardware product of a real-time system for collecting, accounting and managing data transmission of an intelligent transport system in context of the IoT

To cite this article: A L Zolkin *et al* 2021 *J. Phys.: Conf. Ser.* **2094** 052059

Creation of a software and hardware product of a real-time system for collecting, accounting and managing data transmission of an intelligent transport system in context of the IoT

A L Zolkin[1,a], V D Munister[2,b], E A Lavrov[3,c], K G Aygumov[4,d] and O V Saradzheva[5,e]

[1] Computer and Information Sciences Department, Povolzhskiy State University of Telecommunications and Informatics, 23, L.Tolstogo Street, Samara, 443010, Russia
[2] Department of Mathematical Methods and Computer-Aided Design, Private educational institution "Donetsk Academy of Transport", 7, Dzerzhinsky Street, Donetsk, 83086, Ukraine; Department of Enterprise Economics, State educational institution of higher professional education "Donetsk National Technical University", 2, Shibankova Street, Pokrovsk, Donetsk region, 85300, Ukraine
[3] Computer science department, Sumy State University, 2, Rymskogo-Korsakova Street, Sumy, 40007, Ukraine
[4] FSBEI HE «Dagestan State Technical University», 70, I. Shamyl Ave., Makhachkala, 367030, Russia
[5] Economic security, controlling and audit department, Russian State University named after A.N. Kosygin, 33, Sadovnicheskaya Street, Moscow, 115035, Russia

E-mail: alzolkin@list.ru[a]; tilandiya@yandex.com[b]; prof_lavrov@mail.ru[c]; AyKamil@mail.ru[d]; olgasaradjeva@icloud.com[e]

Abstract. Some aspects of the functioning of modern microcontrollers of the Internet of Things in conditions that are close to real-time systems are reviewed in the article. Attention is paid to the aspects of the theory of physical data transmission, the significance of the delay metrics in the data transmission path is substantiated and emphasized. These delays (in view of the generalization of measurement results) determine the control accuracy and controllability of the data processing system as a whole, and also affect the reliability of the results. The process of formalization of the architectural template of a data collecting and accounting system for a control device (which is widespread in intelligent transport systems and the Internet of things) is described. The practical application of the approach in synchronous control through the implementation of a web interface and a control language in a microprocessor system (which can be possible at low traffic transmission rates) is substantiated. In conclusion, a generalization of the scope of application of the developed specialized computer system in transport field is given.

1. Rationale

Rapid development of the Internet of Things concept sets a number of criteria for the functional provision of "ambient intelligence" control devices.

The parametric nature of the operation of almost all existing digital and analogue devices determines the requirements for the presence of a high (maximum) value of observance of unity, relevance, consistency and reliability and promptness of measurements.

By the timeliness of measurements, a complex category is meant. The predicate of this category is the need for clocked (both asynchronous and synchronous) process control: from the beginning of reading of the results from a sensor or actuator, primary processing with subsequent transmission and subsequent addiction from the "upper layer" of the control system (directly by the operator (human)).

By relevance, both the degree of compliance with the needs of end users of the IoT, and the degree of compliance with the unified and standardized approach to cybernetic information processing are meant. And if the second aspect, in general, is observed, which is explained by the delegation to the technologies of the physical layer of data transmission, then the first is not always, and not everywhere. This is explained by the relevance of the data or the property of data (arising from the "promptness"), in other words information that is the object of storage and transmission of information.

This work sets the goal of implementation of a means of operational monitoring and control of digital and analogue IoT sensors used in low-voltage intelligent systems in transport, which will be solved through the development of a software and hardware system for operational dispatch control and management of the state of the single-chip ESP8266 system, which is widely used in smart automation systems. The research objectives are as follows:

- to develop a specialized computer system for a wireless gateway for an intelligent transport network;
- to implement support for the control language, which allows making decisions about control strategies based on current conditions and allows you streamline ESP control in accordance with the needs for some actions, in other words to provide support for adaptive control;
- to ensure the collection of data on the controlled operational process and visualize it in the form of graphic means;
- to formalize the process control model based on the collected data and rules (criteria), the implementation of which ensures the greatest efficiency and safety.

Thus, the subject of research is a cybernetic system with the functions of selection of information about technological processes and provision of a convenient human-machine interface with an operator, while maintaining the history of the process and implementing automatic control of the process through various information and communication means.

2. Aspects of functioning of microprocessor systems in systems close to real time, the importance of jitter minimization

Data collection and accounting systems in the IoT are a new direction of automation of production processes and production based on computer technology and specialized software, adapted to the technical features of inexpensive single-chip systems - which are well suited for ensuring the process of collection of information from remote points (objects) for processing, analysis and possible management of remote objects through various web interfaces.

The novelty of the studied topic is explained by the fact that earlier such systems were used exclusively in bulky control systems for automated operational processes. High requirements for hardware content were imposed to such system. Even solutions of industrial Internet of Things (which is a formal model for the development of smart control systems, taking into account the principles of Indutry 4.0) dose not propose it.

It is something that shall be covered in more details due to the multi-criteria assessment of the role of the hardware component in context of real-time control systems from the point of the information transmission medium [1].

Studies that touch upon the study of the development of hardware requirements for the implementation of functionally significant components of transmitting modules of cyber-physical systems in most microprocessor-based systems are reduced to determination of temporary connection failures and determination of collisions mediated through time-measured terms such as ping and jitter. In other words through delay variations, such as the most significant (but not the only) categorical requirements that determine the fundamental aspect of the telematic interaction path (see figure 1).

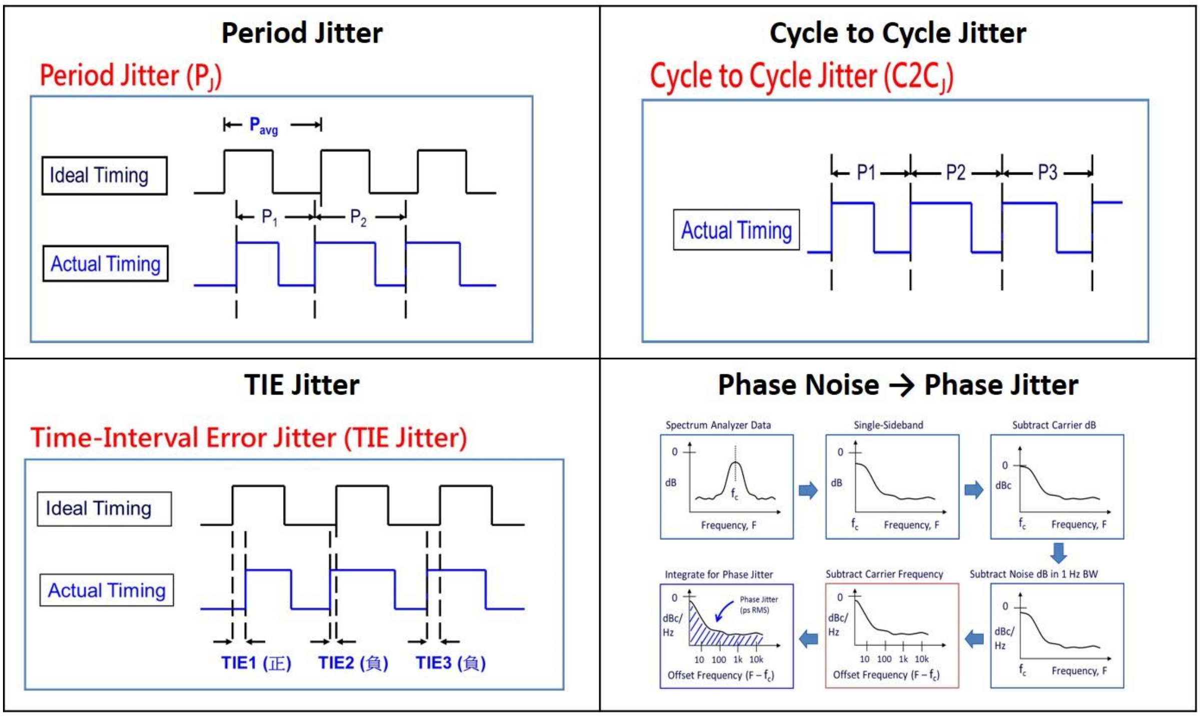

Figure 1. Jitter - characteristics and types for digital transmitters.

Since the communication channels for modern dispatching systems that are very diverse, the choice of a specific traffic management solution depends on the system architecture, the distance between the dispatching unit (MTU) and the RTU (remote workplace), the number of controlled points, they express the bandwidth requirements and reliability of channels, as well as the availability of commercial communication lines.

The trend in the development of traffic management systems as a structural component of SCADA systems can be considered as use not only through the analysis of dedicated communication channels, but also corporate computer networks and specialized industrial networks (industrial buses - CAN, etc.). In modern industrial, electrical and transport systems, industrial networks have gained great popularity - specialized high-speed communication channels that effectively solve the problem of reliability and noise immunity of connections to different hierarchical levels of automation.

Based on the categorical apparatus of the requirements for the SCS being developed, we will rely on the construction of a data model that would directly relate to the aspects (requirements for functioning) of SCADA systems built on various kinds of time specifiers (see figure 2).

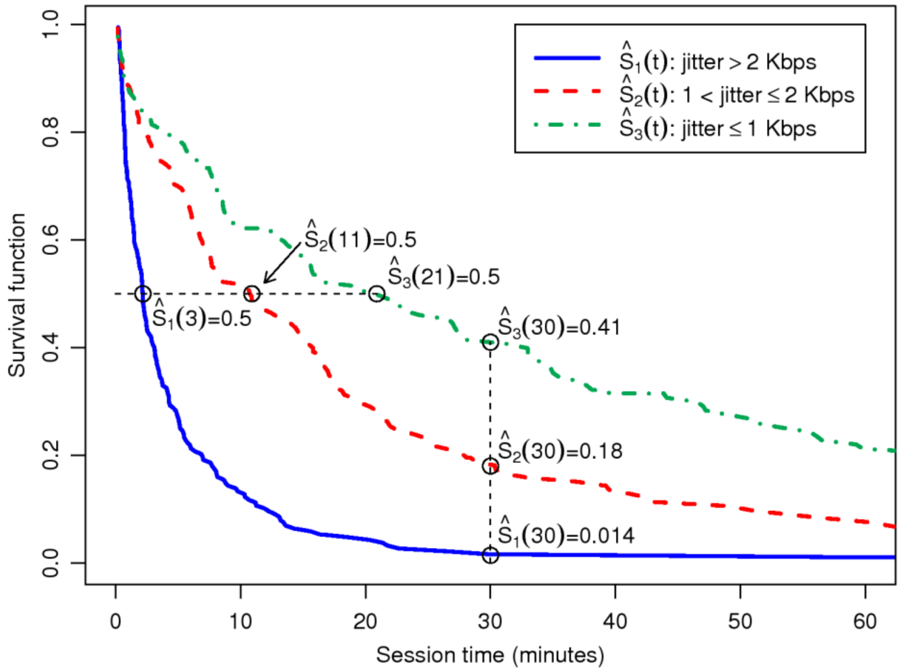

Figure 2. Survival curves for sessions with different bitrate levels (on the example of representation of VoIP /SIP/TCP-IP traffic transmittance to ESP8266).

Based on figure 2, it becomes obvious that it is necessary to develop an architectural solution that implies a minimum (adequately) available data transmission rate to achieve minimum values of time delays, and as a consequence, a decrease in the curve of loss of packages with data in real-time systems within the framework of the IoT concept.

The best jitter performance was demonstrated in the exchamge pathway by IEEE 802.11 (Supportive Technology for Information Exchange) for packages with a total rate of 2 Kbps (0.014 ms for a 30 minute session). For certain reasons these values are undoubtedly insufficient (although there is a tendency to use LoRaWAN as a reference technology for information transfer), for full-fledged data collection systems, however, they suggest earlier assumptions regarding finding the minimum available and adequate values for the requirements to compliance with the rules for the functioning of real-time systems [2].

To implement the operation of the software and hardware platform and architectural solution, an ESP8266 (ESP-12F) microprocessor module operating in IEEE 802.11n has been selected. This module has the ability to operate in the telematic mode at 9600 baud /s, which is equal to 7.68 kb/s.

3. Master data in software and hardware system and data management tool for a developed specialized computer system

The attractiveness of maintaining a low bandwidth for the developed analytical platform is due to the fact that existing solutions (microprocessor systems) for the Internet of Things, firstly, cannot provide a high rate of operation of integrated transceivers, and secondly, they are aimed at use in conditions of low consumption [3].

The designed developed system had requirements for working through a web interface, via HTTP, and implementing an API for remote and local management.

The database has been implemented through the master data templates (MDM), which are widely used in business systems and intelligent transport systems.

Master data are metrics for SCADA with the most important for data for maintaining an informatization facility: about customers, performance, malfunctions, operators, technologies, status of sensor connections, etc. [4].

The purpose of master data management is to make sure that there is no incomplete and inconsistent data in real time by simplifying the data transmission system in the external loop (it is necessary to store all data in the device memory, and transfer only those that are necessary for exchange session (separate metrics for specific (set by the operator remotely) scales from peripheral devices): sensors and actuators, which simplifies the use of a specialized computer system in various fields of activity and informatization facilities.

The Master Data Management template (figure 3) on the one hand shall provide customization for working with data on a specific object, and on the other hand shall be independent from the specifics of the application industry, the scope of the product built on its basis and its information environment [5].

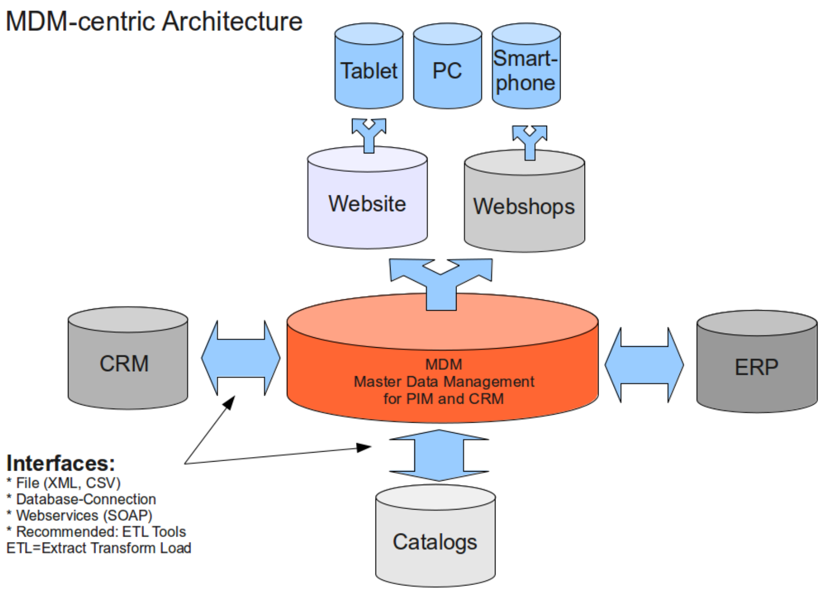

Figure 3. MDM is a template for organizing data and software tools for master data management, built on interoperability with business and project management systems.

The SCADA software developed by IDEArduino is based on the C language for the ESP-12F, which has an IEEE 802.11 module.

The control language of the collection and dispatching system is implemented both through a direct control interface and a web server implemented via HTTP, as well as through an AT construct formalized through the BS-88 control language, which is defined by the ISA-88 standard. One control command takes 512 bytes of traffic.

The current edition of the control standard includes the necessary organizational and technical standards used in SCADA systems:

- part 1: Models and Terminology ANSI /ISA-88.00.02-2001 Package Management;
- part 2: Data Structures and Recommendations for languages ANSI / ISA-88.00.03-2003 Package Management;
- part 3: General models and presentation of site in ANSI / ISA-88.00.04-2006;
- part 4: Serial production records ISA-TR88.00.02-2008 State of machines and units.

The control is based on the regulation of the discrete (D) and analogue (A) ports, the reading itself is realized through hardware interrupts.

The developed SCADA integrates a full-fledged automated control through an integrated approach to the definition of master data and flow control of discrete Input /Output lines in the configuration mode ("SETUP)" (see figure 4).

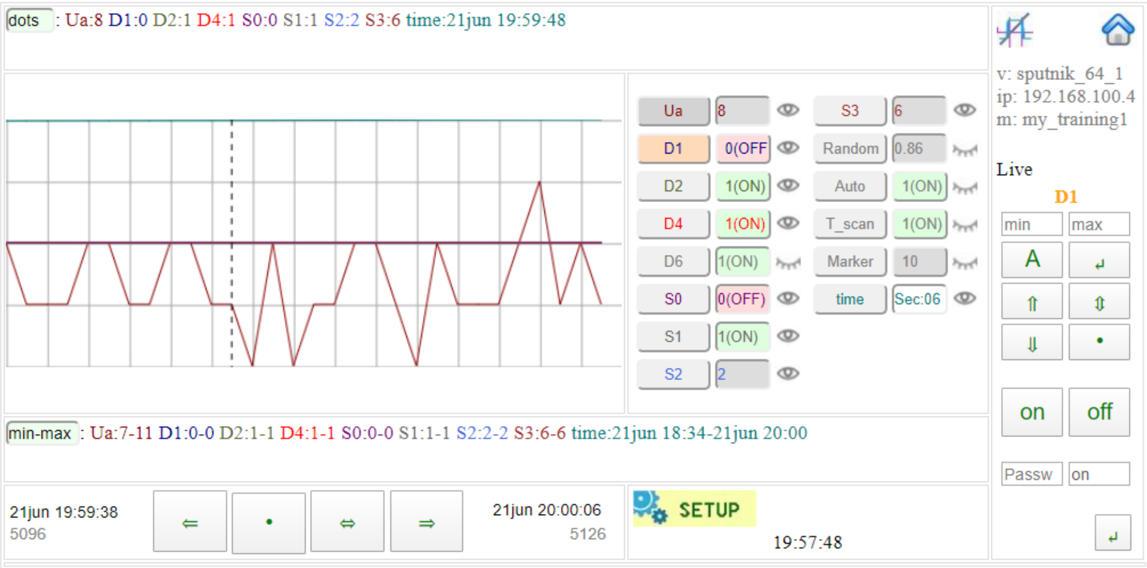

Figure 4. Web Interface of the developed SCADA.

Operators (active statement, action statements) can turn devices on / ff, perform intermediate calculations, send emails, display variables on the panel, etc. Each action statement is executed once per phase, then a transition state is expected: if (condition) trans {label}; or simply without the conditions trans {label}; When active commands are running and a condition is awaiting, the $ timer variable is incremented once per second. Thus, a time relay can be made.

Let's turn on $ D3 for 45 seconds using the syntax of the control language (in order to do it the designated input must be set to a positive one):

7: $D3 = 1;

if ($ timer> = 45) trans {8}; // On this line, the algorithm seems to 'get stuck' (go into a controlled interrupt) until the condition is met

8: $D3 = 0;

Such control structure is not like a usual device programming language, where one statement is executed at each step [6].

Note: the system provides one more statement - the "stop" statement, which stops the execution of the script. However, in this case, the AUTO field will remain enabled on the panel.

Special variables (functions)

One such variable - $ timer, has been reviewed but there are others.

$ntime - [n] ow [time] - current time; used as a floating point number 13.4 means 13 hours and 40 minutes

$random - random number [0: 1] (used to simulate life in an empty house)

$morning - start of the day for mid-latitudes (used to turn off the lights)

$evening - sunset time (used to turn on the lights)

$retro - timer value that timer has reached in the previous phase

$temp - current temperature value from ds18b20 temperature sensor connected to D5

$ptime - time in seconds from the beginning of the scan period, equal to T_scan.

The functions of the developed web control are mediated through the implementation on Web-sockets through:

M (); - send mail; in brackets any text with the names of the variables. Their values will be used instead of their names (Email is entered on the configuration page)

T (); - send to Telegram; in brackets any text with the names of the variables. Their values will be used instead of their names (Token and Id of the chat are entered on the configuration page)

E ($ Sx), where x - 0,1,2,3,4 - remember the $ Sx variable in EPROM. See the note for details.

The condition in the transfer statement consists of creation of expressions in parentheses, and logical signs between them: =,>, <,> =, <=, <>

For example, turning off the light in a vehicle (pin D1) one hour before sunrise, and turning it on at 22:00, sending a letter in accordance with the changes is implemented through the following pseudo-code:

```
1: $ D1 = 1;
M (Light_on_at_ $ntime); // Send the e-mail
if ($ntime> = $morning ~ 1) trans {2};

2: $ D1 = 0;
M (Light_off_at_ $ Ntime); // Send the e-mail
if ($ ntime = 22.00) trans {1};
```

Note on use of time and minus sign:

$ morning ~ 1 one hour before sunrise (determined by the intelligent subsystem of the server part of adaptive intelligent transport system);

If any error occurs, the compiler provides an information about it in the "last_error" line on the configuration page. The script checking is started before its' launching The script starts by pressing the AUTO key on the control panel. Sometimes some events need to be counted, for example. Pulses from a Geiger counter. For this purpose, the developed SCADA always monitors the output D0 and increases the variable $ X0 by 1 when the status of D0 changes. In a real sketch, the counter is used as follows [7,8].

```
1 :;
if ($ptime = 30) trans {2};

2: $ S0 = $ X0; displaying the counter for 30 seconds
$ X0 = 0; // reset the counter
trans{1};
```

4. Findings

Thus, the developed control system is adaptive to the conditions of low data transmission rate - which ensures the minimum time delay of operation, which is calculated in hundredths of milliseconds. Requirements for the minimum data transfer rate while approaching the Master-data organization are positively correlated with real-time mobile systems, which allows them to be used in digital ecosystems in transport [9,10].

The architectural and software approach to the implementation of control of the developed SCADA allows the use of a software-analytical system in low-power and low-voltage systems with outdated wireless communication information transfer standards, which makes it possible to use them in the developing digital economies of the world [11,12].

References

[1] Bailey D and Wright E 2003 Practical SCADA for industry *Elsevier*
[2] Suaboot J *et al*. 2020 A taxonomy of supervised learning for idss in scada environments *ACM*

Computing Surveys (CSUR) **53(2)** 1-37
[3] Thite S and Naveenkumar J 2021 FASSSTeR: A Novel Framework Aligned with ISA and ISO Standards for Cyber Physical System Safety, Security, Sustainability and Resiliency *Design Engineering* 399-411
[4] Upadhyay D and Sampalli S 2020 SCADA (Supervisory Control and Data Acquisition) systems: Vulnerability assessment and security recommendations *Computers & Security* **89** 101666
[5] Myint A K *et al*. 2021 *IoT-Based SCADA System Design and Generation Forecasting for Hydropower Station*
[6] Rustandi D *et al.* 2021 Automatic Waste Transport Equipment in the River Integrated With the SCADA System *6th UPI International Conference on TVET 2020 (TVET 2020) Atlantis Press* 217-20
[7] Taberko V V *et al*. 2020 Principles for enhancing the development and use of standards within Industry 4.0 *Open semantic technologies during designing of smart systems* **4** 167-74
[8] Delfani F, Samanipour H, Beiki H, Yumashev A and Akhmetshin E 2020 A robust fuzzy optimisation for a multi-objective pharmaceutical supply chain network design problem considering reliability and delivery time *International Journal of Systems Science: Operations and Logistics* 1-25
[9] Zolkin A L, Domracheva E A, Losev A N and Avdeev Yu M 2021 Use of the modern information technologies for continuous monitoring of transport infrastructure *IOP Conference Series: Materials Science and Engineering* (Krasnoyarsk Science and Technology City Hall Krasnoyarsk Russian Federation) 12094 DOI: 10.1088/1757-899X/1047/1/012094
[10] Tormozov V S, Zolkin A L and Vasilenko K A 2020 Optimization of neural network parameters based on a genetic algorithm for prediction of time series *International Multi-Conference on Industrial Engineering and Modern Technologies FarEastCon 2020* 9271536 DOI: 10.1109/FarEastCon50210.2020.9271536
[11] Vlasova Natalya V, Kuznetsov Dmitry V, Mehdiev Shamsaddin Z, Timofeeva Ekaterina S and Chistyakov Maxim S 2019 Information Technologies in the Context of Forming the Synergy of Post-industrial Consciousness and Digital Economy *ISC 2019: Modern Global Economic System: Evolutional Development vs. Revolutionary Leap* 1241-7 DOI: 10.1007/978-3-030-69415-9_135
[12] Lavrov E A, Paderno P I, Volosiuk A A, Pasko N B and Kyzenko V I 2019 Automation of Functional Reliability Evaluation for Critical Human-Machine Control Systems *In Proceedings of 2019 3rd International Conference on Control in Technical Systems, CTS 2019* 144-147 Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/CTS48763.2019.8973294